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Interactive comment on "Comparing tide gauge observations to regional patterns of sea-level change (1961–2003)" *by* A. B. A. Slangen et al.

Anonymous Referee #2

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The submitted manuscript examines the contribution of a number of processes to regional/local variations in the linear trend of sea level for 1961-2003, as measured by a selected set of 278 tide gauges (no GPS corrections applied). Contributions include changes in: atmospheric pressure loading, land ice mass, terrestrial water storage (dam impoundment + groundwater extraction), dynamic sea level (steric + OBP) and GIA. The latter two appear to be the dominant contributions. Improved agreements are obtained over regionally-averaged areas than at individual sites.

The manuscript is generally well-written, addresses a relevant sea level question and is suitable for publication in ESD. Prior to publication, however, I suggest the manuscript be revised to address some concerns (and minor details) as explained below.

General comments:

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Interactive Discussion
Discussion Paper

(1) Results/uncertainties/robustness conclusions:

(1a) – I strongly agree with the comment from Reviewer#1 copied below.

“I felt, however, that we need to see the uncertainties in each the contributions (as well as a total – as shown in Fig.8a) and in the TG data. This would give a sound base on which to view the global ïňĄndings, especially since we sometimes look at relatively small numbers.”

(1b) – Could the findings be dependent on the specific choice of data sets used for the contributions, particularly the dominant GIA (e.g., Peltier and Paulson?) and steric (e.g., Levitus and Ishii?) components, given that there are known regional differences between published products? For example:

Fig. 6 in Feng et al. (2013) shows differences between the Peltier and Paulson GIA models along parts of the European coast, over their study period.

Fig. 11 in Cazenave and Nerem (2004) shows differences in regional long-term trend patterns between Levitus and Ishii thermosteric sea level products.

I suggest the authors to briefly articulate why they might have preferred/selected specific data products/models (as done, for instance, for the set of tide gauges and glacier observations used) and discuss in section 4 how these choices might influence their regional/local results.

(1c) – Church et al. (2011) showed that there are larger uncertainties affecting estimates of the contributions in the 1960s for the global sea level budget (their Figure 2b). In the latest IPCC AR5, the global sea level budget was assessed from 1970s rather than 1960s (Church et al., 2013, Box 13.1, Fig. 1).

So, would it be relevant to consider the 1971(2)-2003 trend period in the submitted manuscript? (at least to test whether it might have any influence on results)

(2) Results/discussion: new results/previously published results/conclusions

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The level of the discussion (section 4) is not as strong as it could be for three reasons:

(i) It is entirely devoted to the closure of the global sea level budget while the results of the submitted manuscript mainly concern regional/local budgets. These new regional/local results should be discussed in view of previous published literature to clarify improvements (e.g., more contributions and locations considered, reduced uncertainties, etc).

I also noted that there are no similar published studies (background, e.g.: Plag, 2006) cited in the introduction (section 1) and that, in several occasions, results in terms of expected spatial patterns (Section 3) which have been described before in the literature are not associated with a citation (e.g., Tamisiea and Mitrovica, 2011).

(ii) Please see comment (1b).

(iii) The authors might not be aware of a recent publication by Wöppelmann et al. (2013, accepted online February 13, published March 6, 2014) in which a set of tide gauges have been corrected using GPS (under 2 main assumptions).

Some of the tide gauge locations used in Wöppelmann et al. (2013) are likely to overlap with the tide gauges used in the submitted manuscript. So, the quality of the manuscript will certainly benefit if it further considers in its results/discussion the overlapping set of tide gauges with GPS correction and any implications for the conclusions of the paper.

(3) Description of data sets/traceability calculations:

The description of the data sets/"models" used is rather incomplete. For example:

It is not until page 180, line 25, that the reader finds that the net contributions are on a 1 x 1 degree grid.

Data sets tend to have continuously updated versions. What is the downloaded version for the steric contribution from Levitus? Download date? Grid resolution? Although it is mentioned "monthly gridded" (page 174, line12), could the temporal resolution actually

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be yearly or pentadal?

The approach used by Landerer et al. (2007) is cited to include the effect of changes in ocean bottom pressure but there is no self-contained/brief explanation for the reader to quickly understand how the calculations were performed.

I suggest the authors to provide a brief description in the text for data sets/calculations and relevant details as part of a supplementary material section. As part of the suppl. material, I would also suggest the inclusion of a series of spatial maps for individual contributions which were combined in Fig.2. For example:

- Greenland ice sheet

- Antarctica ice sheet

- steric 0-2000 m: temperature plus salinity (SSH)

- steric >2000 m: temperature plus salinity (SSH)

- OBP (SSH)

- dam impoundment (TWS)

- groundwater extraction (TWS)

And, if ESD permits, to make results/maps available online after publication.

Minor details:

- page 171, line 8: new reference available: Holgate, S.J.; Matthews, A.; Woodworth, P.L.; Rickards, L.J.; Tamisiea, M.E.; Bradshaw, E.; Foden, P.R.; Gordon, K.M.; Jevrejeva, S., and Pugh, J., 2013. New data systems and products at the Permanent Service for Mean Sea Level.

- page 171, lines 11-17: " process that is not included in this study is vertical land movement from subsidence or tectonics. These changes can be measured by GPS, which can then be compared to the TG time series, but only for short time series and in

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limited locations (e.g., Han et al., 2014). In this study we therefore focus on how much 15 of the regional sea-level measurements can be explained without or before the use of GPS. Tide gauge measurements that are clearly affected by vertical land motions are therefore discarded (Sect. 2.1)."

Please see Wöppelmann et al. (2013) and relevant references therein.

- page 173, line 16: "per region"

What were the criteria used to divide into regions? Based on previous literature (e.g., Jevrejeva et al., 2006)? How the tide gauges from one region correlates with each other?

- page 175, lines 25-26: for example, could refer the reader to suppl. material for OBP spatial pattern if it is made available.

Two examples of possible missing citations:

- page 176, lines 3-4: "The AL pattern (Fig. 2e) shows a strong meridional signal, indicating a decrease of pressure near the poles and an increase in equatorial regions."

Has this pattern been observed/discussed before? Citation?

- page 186, lines 1-4: "From Sect. 4, it appeared that the closure of the global mean sea-level budget really depends on the period that is chosen. Uncertainties in the measurements of the contributions, such as ocean temperature or glacier mass change, rapidly increase when going back further in time."

Citation?

References

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Interactive comment on Earth Syst. Dynam. Discuss., 5, 169, 2014.